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ABSTRACT

This teacher's guide presents teaching suggestions and presentation materials on the hidden environmental costs of driving automobiles through examining the history of the automobile and looking to the future for alternatives. The lesson is divided into six parts and may be completed in four or more class periods. Student handouts include: (1) "Car Talk"; (2) "Test Yourself: How Much Do You Know about Motor Vehicle Usage?"; (3) "Answers to 'How Much Do You Know about Motor Vehicle Usage?'"; (4) "How Do Motor Vehicles Contribute to Air Pollution?"; (5A) "The Road We Traveled: Text"; (5B) "The Road We Traveled: Graphic Timeline"; (6) "Taking Action: What Can You Do?"; (7) "What Are the Alternatives?'; and (8) "Taxi 2000: Personal Rapid Transit." Transparency masters are titled: (1) "The Hidden Costs of Driving"; (2) "Emission: A Triple Threat"; (3) "Number of Vehicles in the World"; and (4) "Motor Vehicles in World Regions." (EH)

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TEACHER'S GUIDE

to World Resources

Car Trouble

ED 461 560

SO 028 466

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Teacher's Guide

to

World Resources:

Car Trouble

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Teacher's Guide

to

World Resources:

Car Trouble

Comprehensive Coursework on the
Global Environment

World Resources Institute
1709 New York Avenue, N.W., Washington, DC 20006

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The World Resources Institute (WRI) is a research and policy institute helping governments, the private sector, environmental and development organizations, and others address a fundamental question: How can societies meet human needs and nurture economic growth while preserving the natural resources and environmental integrity that make prosperity possible?

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Using World Resources Teacher's Guide Units

World Resources *Teacher's Guide* Units are designed for use at the secondary school level (although we have reports of successful use at the middle school and college levels). They weave together lessons about both environment and development, both globally and locally. They draw on skills and knowledge from the physical and biological sciences, social studies, history, economics, civics, and global studies.

Information and analysis used in the Units are drawn from World Resources Institute (WRI) publications and databases. All units are written by curricula writers and reviewed by educators as well as by technical experts. The Units are updated and revised periodically based on feedback from classroom teachers who have used the materials.

Our intent is to provide easy-to-use, inexpensive classroom materials that contain the most recent and authoritative information on the global environment because we believe it is crucial that the next generation of leaders and citizens understand the issues described here.

The complete set of *Teacher's Guide* Units includes the following topics:

- Biodiversity
- Car Trouble
- Citizen Action
- Energy, Atmosphere, and Climate
- Natural Resource Economics
- Oceans and Coasts
- Population, Poverty, and Land Degradation
- Sustainable Development
- Two Giants: China and India
- Watershed Pollution
- Women, Equity, and Sustainable Development

These units have been revised and updated with the most recent data available as of spring 1994.

Inside Each Unit

Each *Teacher's Guide* Unit should contain enough teaching suggestions and presentation materials to teach one to several classes on the topic without securing additional resources. On the other hand, each unit is designed to point teachers and students to additional resources and to offer suggestions for expanded coursework. Specifically, each unit contains objectives, a lesson plan, student handouts, overhead transparency masters, student enrichment activities, suggestions for further reading, and suggested audiovisual resources.

Using the Units for Environmental Studies

The *Teacher's Guide* Units provide a comprehensive, consistent yet highly flexible set of materials for environmental studies courses. They can be used in conjunction with an environmental science textbook to give students an understanding of basic environmental systems and cycles. Or they can be used in a social studies context to examine some of the tough problems and choices we face as a society.

Educators who want to go beyond the *Teacher's Guide* Units can read related WRI publications, which provide the basic data, source materials, and analysis for the Units. These publications are listed at the beginning of each unit. A free catalog can be obtained by calling 1-800-822-0504.

Integrating Teacher's Guide Units into the Curriculum

Secondary school teachers frequently mention the difficulty of integrating environmental issues into a tightly packed curriculum. As much as they would like to teach about the environment, they must devote class time to required subjects.

To help them place these issues in their curricula, we have coded each lesson plan and each student enrichment activity to the draft national performance assessment standards for science, math, history, civics, and geography. These standards are being developed as part of the national Goals 2000 program in the U.S. Department of Education. The standards themselves are being developed, discussed, and revised by educational organizations in nine academic disciplines. They are expected to be approved at the national level, then offered to states to incorporate into their own academic assessment plans. Although this process will take several years, we have compiled lists of assessment standards for grades 9 through 12 from drafts available in spring 1994 to offer some guidance to teachers.

A complete list of the draft standards for Grades 9 through 12 appears in Appendix B, which should be mailed to you with your order. Appendix A provides a bibliography and list of related organizations. A cover suitable for inserting in a clear-view binder is enclosed with the appendices.

Integrating Global Environmental Education into High School Curricula

In an effort to link lessons about global environment and development issues to required school curricula, we have identified which pages of the lesson plan and which student enrichment activities in this *Teacher's Guide* Unit relate to the draft national performance standards developed recently for civics, geography, history, math, and science in grades 9 through 12.

These voluntary national standards are part of the Goals 2000 program mandated by the Goals 2000: Educate America Act of 1994 under the direction of the U.S. Department of Education. Among other things, Goals 2000 will establish a set of goals or performance standards for grades 4, 8, and 12 in the subjects listed above plus English, the arts, and foreign languages. These goals will be available to the states for incorporation into their own sets of educational performance standards. Each set of draft standards was developed by a professional education organization and has been presented at numerous educational conferences for review and comment. The draft standards used here are those available as of spring 1994.

Although many countries have national performance standards, the United States (and Canada) have treasured a decentralized educational system that sets education goals at the district or state level. Goals 2000 is the first attempt to identify a set of general education objectives that all students in the country are expected to achieve. As might be expected, there is some controversy over whether there should be national education goals—even voluntary ones—and if so, what they should be.

Regardless of the final outcome, we feel the draft goals do reflect some consensus among educators about what material should be covered at various grade levels, and as such, offer some guidance for integrating environmental education into the curricula.

Only those goals relevant to this unit are listed here. A complete list of goals appears in Appendix B. Copies of reports outlining the goals for each subject area can be obtained from the education organizations listed at the top of each set of goals on this page. Information about the Goals 2000 program is available at 1-800-USA-LEARN.

Goals 2000: Draft National Performance Standards

Civics and Government*

(Draft National Standards, October 1993, Center for Civic Education, 5146 Douglas Fir Road, Calabasas, CA 91302-1467)

	Lesson Plan Page Number	Enrichment Activity Number
III. How Does the Government Established by the Constitution Embody the Principles and Purposes of American Democracy?		
6. How is public policy formulated and carried out?	10	
V. What are the Roles of the Citizen in the American Political System?		
4. How can citizens participate in public life?	9	5

Geography*

(Draft National Standards, October, 1993, National Council of Geographic Education, Geography Standards Project, 1600 M Street, NW, Washington, DC 20036)

	Lesson Plan Page Number	Enrichment Activity Number
I. Seeing the World in Spatial Terms		
1. Knows and understands how to use maps, globes, and other graphic tools and technologies to acquire, process, and report information from a spatial perspective.	3, 4, 8	6, 8
IV. Human Systems		
11. Knows and understands patterns and networks of economic interdependence on Earth's surface.	6	
12. Knows and understands the processes, patterns, and functions of human settlement.	3, 4, 6, 8	6
13. Knows and understands the forces of cooperation and conflict that shape the divisions of Earth's surface.	6	

Note: Only the education goals relevant to this unit are listed.

V. Environment and Society		
14. Knows how Earth's dynamic physical and human systems are connected and interact.	4, 6, 8	
15. Knows the consequences of the interaction between dynamic human and physical systems.	4, 6, 8	7
16. Knows changes in the meaning, distribution, and importance of resources.	5, 6, 8	
VI. Applying Geography		
17. Knows and understands how to apply geography to interpret the past.		6
18. Knows and understands how to apply geography to interpret the present and plan for the future.		6

History*

(Draft National Standards, October 1993, National Center for History in the Schools at UCLA, 231 Moore Hall, 405 Hilgard Avenue, Los Angeles, CA 90024)

	Lesson Plan Page Number	Enrichment Activity Number
I. Historical Chronology		
1. Distinguish between past, present, and future time.	7, 8	
6. Interpret the data presented in time lines.	7	
II. Historical Comprehension		
4. Draw upon the data in historical maps.		6
6. Draw upon the visual data presented in photographs, paintings, cartoons, and architectural drawings.		6
IV. Historical Analysis		
2. Incorporate multiple causes in analysis and explanations of historical action, including the role of chance, the accidental, and the irrational.	7	
4. Demonstrate and explain the influence of ideas, human interests, beliefs and ideologies on individual and group historical actions and their consequences.	7	
5. Hypothesize the influence of the past on the present.		6
V. Historical Research		
2. Obtain needed historical data from a variety of sources including: library and museum collections, historic sites, historical photos, journals, diaries, eyewitness accounts, newspapers, and the like; documentary films; and so on.		6

Mathematics*

(Draft National Standards, March 1989, The National Council of Teachers of Mathematics, Order Processing, 1906 Association Drive, Reston, VA 22091)

	Lesson Plan Page Number	Enrichment Activity Number
X. Statistics		
1. Construct and draw inferences from charts, tables, and graphs that summarize data from real-world situations.	3	

Science*

(Draft National Standards, February 1994, National Academy of Sciences, National Research Council, 2101 Constitution Avenue, NW, Washington, DC 20418)

	Lesson Plan Page Number	Enrichment Activity Number
II. Physical Sciences		
2. Chemical Interactions	6	7
3. Forces and Motion		9
III. Life Science		
4. Ecosystems and Human Ecology	1, 3-11	1-7
IV. Earth & Space Science		
2. Biochemical Processes/Cycles in Earth Systems		7
VI. Science and Technology		
1. Problem Identification	8-10	
2. Solution Design-Cost, Risk-Benefit Analysis	8-11	
4. Solution Evaluation	8-11	4
VII. Science and Societal Challenges		
1. Population Growth	7, 8	
2. Natural Resources	1, 3-11	1-9
3. Environmental Degradation	1, 4-11	1-9
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Car Trouble

For most of us in North America, automobiles are a necessity. Automobiles affect how and where we live. Most of us commute to work by driving. We use our cars to shop, to get to school and religious services, to visit the doctor and our friends, and to go on vacation. A substantial part of our income goes to pay for our automobiles.

Car advertisements promise us not just practical transportation, but luxury and performance, social status, and sex appeal. Interestingly, some recent ads have included mention of the environment. Ironically, one describes a new car's glossy coating that protects against the sun's harmful UV light and "even acid rain." There is no mention that automobile exhaust contributes to increased UV radiation and acid rain.

As the numbers of automobiles climb, and motor vehicle usage increases in North America and around the world, concern about their environmental costs grows. There are other costs, too, such as traffic congestion and dependence on imported oil in particular and fossil fuels in general.

Our students' generation will begin the major transition from fossil fuel-based energy to energy based on renewable sources. Although this transition may seem inconceivable to us, energy experts consider it inevitable. Today's students will someday drive cars powered by electricity, hydrogen, or other sources now under development. They may even contribute to the development of new cars, new fuels, or new modes of transportation.

This lesson begins by asking students to examine their own use of motor vehicles. Facts about motor vehicle usage are introduced to provide a context. Students then examine the hidden environmental costs of driving. Next, they look back at the automobile's history to see how our dependence on the gasoline-powered automobile developed. Students then examine how motor vehicle emissions pose a triple threat to the environment, especially considering that they are projected to increase. Finally, students consider what they can do to address the problems outlined in the lesson and prepare for the future.

This lesson was developed from information in several publications of the World Resources Institute. *Car Trouble* by Steve Nadis and James J. MacKenzie is recommended as a companion to this lesson plan. The chapter also draws on the following WRI research reports: *The Going Rate: What it Really Costs to Drive; Driving Forces: Motor Vehicle Trends and their Implications for Global Warming, Energy Strategies, and Transportation Planning;* and *Electric and Hydrogen Vehicles: Transportation Technologies for the 21st Century*. Additional information was obtained from *World Resources 1994–95*. Some statistics were updated with information from the *Statistical Abstract of the United States* (U.S. Government Printing Office, Washington, D.C., 1993), *AAMA Motor Vehicle Facts and Figures '93* (American Automobile Manufacturers Association, Detroit, 1993), and *The State of Canada's Environment* (Government of Canada, Ottawa, 1991). Also see **Suggestions for Further Reading** and the order form at the end of this guide.

Objectives

By the time they finish this lesson, students should be able to:

- Describe their own driving patterns and compare them with national patterns.
- Distinguish between the direct costs of driving paid by individuals and the indirect costs paid by society.
- Explain how motor vehicle use contributes to air pollution, global warming, and ozone depletion.
- Identify ways to deal with traffic congestion, environmental damage, and dependence on imported oil.
- Identify actions that individuals, communities, and nations can take to reduce the environmental impact of motor vehicles.
- Think creatively about alternative modes of transportation and alternative fuels for the future.
- Make value judgments about driving patterns and practices and examine (and change, if appropriate) their own behavior accordingly.

Teaching Strategies

This lesson is divided into six parts. If you wish to follow the lesson plan, allow 4 to 5 class periods. The lesson is quite flexible, and each part may be enhanced with additional materials or enrichment activities.

The lesson includes the following materials that may be duplicated:

Student Handouts

1. Car Talk
2. Test Yourself: How Much Do You Know About Motor Vehicle Usage?
3. Answers to "How Much Do You Know About Motor Vehicle Usage?"
4. How Do Motor Vehicles Contribute to Air Pollution?

5A. The Road We Traveled: Text
5B. The Road We Traveled: Graphic Timeline

6. Taking Action: What Can You Do?
7. What Are the Alternatives?
8. Taxi 2000: Personal Rapid Transit

Overhead Transparency Masters

1. The Hidden Costs of Driving
2. Emissions: A Triple Threat
3. Number of Vehicles in the World
4. Motor Vehicles in World Regions

Beginning the Lesson

A week in advance of the lesson, distribute to students copies of **Handout 1, "Car Talk."** Point out the directions at the top of the questionnaire: students whose families do not have a car should go directly to question 12. Also point out that while some of the questions may be answered quickly, others require research. As part of this exercise, students are directed to keep a log, recording each trip they make by car, the purpose of each trip, and the number of miles driven. They are also asked to keep a record of trips taken by public transportation (noting costs), on foot, or by bike, etc. Keep a log yourself, and fill out the questionnaire so that you can report your own findings.

Results of the questionnaire can be compiled informally in class, by asking for a show of hands, or formally, by collecting questionnaires and compiling the responses on a blank questionnaire. For comparison, the U.S. national averages for several questions are given below.

Student Travel Patterns

Use the following questions to guide discussion of the questionnaire:

1. *What are students' travel patterns?* How many miles do they travel each week? What is the purpose of most of their trips? For car trips, do they usually drive by themselves or with others? (In 1990, some 84 million U.S. residents drove alone to work and 15 million carpooled. Less than 5 percent of all commuters used public transportation. In Canada in 1980, out of 9.2 million commuters, 6.8 million commuted via 5.7 million private automobiles.)

2. *What are the direct costs of driving?* Which specific costs are greatest? Which costs can drivers control? Which are fixed? In 1991, the average costs of owning and operating an automobile included:

Fixed Costs

Finance Charge (interest on car loan not counting principal): $779
Insurance: $726
License and registration: $169

Variable Costs

Maintenance: 6.7 cents per mile (4 cents per kilometer)
Tires: 0.9 cents per mile (0.5 cents per kilometer)
Gas and oil: 9.8 cents per mile (6 cents per kilometer)

Total cost per mile driven: 44 cents (27 cents per kilometer).

Americans drive an average of about 12,500 total miles (20,112 kilometers) per year; thus, the average annual cost to operate a car per household in the U.S. is $5,500 (12,500 miles times 0.44 cents per mile). Canadians reported spending an average of $4,982 per household to operate their cars in 1986, while spending only $557 on local and commuter transportation.

Another way to look at expenses is to examine our annual transportation costs. In 1992, Americans spent $424 million on user-operated vehicles; $9 million on local subways, buses, and taxis; and $30.6 million on long-distance travel on buses, trains, and airplanes.

3. *What are the benefits of driving?*

4. *How do alternatives—such as using a school bus or public transportation or carpooling—compare with driving in terms of cost, travel time, and convenience?* (The average U.S. travel time to work is 22.4 minutes for all methods of transportation.)

5. *If students who drive no longer had access to an automobile, how would this change their lifestyles?* A challenging assignment would be to ask students who drive regularly to stop driving for a day or a week and describe the alternative plans needed to carry out their daily routine. A total lack of alternatives might be a good topic for discussion.

6. *How did students end up with the cars they currently drive?* If they could buy any vehicle they wanted, what would they choose? Why? (U.S. retail sales figures for 1991 showed passenger cars at about 8 million, mini-vans and small wagons at 2.7 million, pick-ups and large wagons at 875,000.)

During the discussion, bring up the following points:

- Lifestyles in most places in the United States and Canada are built around automobiles, making them a necessity. Younger cities, and the suburbs of older ones, have grown up around the automobile. People tend to live far from jobs and schools, from stores and services. In only a few major U.S. cities, such as New York, Boston, and Washington, D.C., do the public transportation systems rival the convenience of the auto. Automobiles affect how we live, where we live, how we get to work, how much money we spend getting to work, and, to some extent, how we spend our money.

Although the costs of buying and operating cars are high, cars, as a form of personal transportation, offer unmatched convenience, freedom, privacy, and speed (except in congested areas). With a car, you can go wherever you want to and whenever you want to travel.

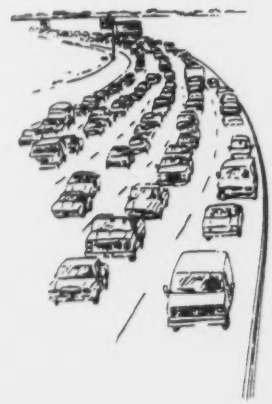
The family car may be viewed as a workhorse, but cars are sold by ads that appeal to humans' needs for security, status, and sexual appeal. We want our car to project who we want to be. Can we still be sexy in a frugal, efficient, nonpolluting car? (See **Student Enrichment Activity 1, "Analyze Advertisements."**)

The Big Picture

To make a transition between students' own use of automobiles and national usage patterns and to provide useful information for understanding trends, have students take a brief quiz using **Handout 2, "Test Yourself: How Much Do You Know About Motor Vehicle Usage?"** Allow about 10 minutes for students to complete the exercise. Discuss the answers using **Handout 3, Answers to "How Much Do You Know About Motor Vehicle Usage?"**

Important points to emphasize in discussing American and Canadian reliance on motor vehicles include the following:

- All of the following are increasing: the number of vehicles, the number of miles driven, traffic congestion, emissions of greenhouse gases, oil consumption, importation of foreign oil, the numbers of junked cars, the amount of land paved over for roads, parking lots, etc.
- All of the following are decreasing: domestic oil production; global resources of oil, a nonrenewable fuel (although currently supplies are good and prices are low); resources used to manufacture vehicles (steel, aluminum, zinc, copper, lead, nickel), although some are being recycled; and ozone in the upper atmosphere. Fortunately, traffic accidents per miles driven are also decreasing.



Hidden Costs: Are Cars a Dream or a Nightmare?

The United States depends on motor vehicles more than any other country. Cars are part of the American dream: they offer convenience, freedom, speed, mobility. But is that dream becoming a nightmare? Is the quest for personal mobility now actually interfering with the good life?

To answer this question, ask students if they can suggest any drawbacks to the growing dependence on automobiles, or any costs to society as a whole. Earlier in the lesson, students discussed the direct costs of driving, those that they or their parents pay for gas and oil, repairs and maintenance, insurance, car payments, parking, etc. Now, encourage them to consider indirect or hidden costs that drivers do not pay.

Compare student answers with information in **Overhead Transparency Master 1, "The Hidden Costs of Driving."**

The following information will be helpful in discussing the costs depicted in the master:

- *Accidents:* In 1991, there were 11.3 million accidents involving motor vehicles in the United States, leading to 43,500 deaths and more than 5 million injuries. The total economic costs were $93.8 billion, including lost wages, legal, medical, hospital, and funeral expenses, as well as insurance administrative costs and property damage. (*Statistical Abstract*, p. 620.)
- *Noise:* Noise from motor vehicles causes stress and fatigue and damages property values.

- *Land loss:* Land used for roads and highways may come from wetlands, watershed regions, parklands, scenic areas, and historic and cultural areas. One third to one half of the land in American cities is used to accommodate motor vehicles; in Los Angeles, the figure is two thirds. (*Car Trouble*, p. 12.)
- *Solid waste:* Every year in the United States, about 8.5 million cars are "retired;" many are abandoned in junkyards or roadsides. Millions of tires are also junked each year, creating fire and air pollution hazards, clogging landfills, and serving as breeding grounds for mosquitoes. (*Statistical Abstract*, p. 617.)

  It has long been possible to dismantle cars for reuse and recycling in the United States; every year this recycling generates about 11 million tons (9.98 metric tons) of recycled steel and 800,000 tons (725,600 metric tons) of recycled nonferrous metals. However, not all materials in a car are recycled, and car manufacturers recognize the need to improve the recycling process.
- *Congestion:* In major urban areas, traffic has steadily increased, leading to traffic delays, stress, loss of productivity, higher vehicle operating costs, excess fuel use, greenhouse gas emissions, and air pollution. Congestion is rapidly getting worse. In the 1980s, traffic in California increased 55 percent while miles of new roads grew by less than 2 percent. In Los Angeles, freeway speeds average less than 31 miles per hour (49 kilometers per hour) and are projected to fall to 11 miles per hour (17 kilometers per hour) by the year 2010. (*The Going Rate*, p. 17.) Delays and fuel cost waste an estimated $780 million a year—an average of $440 per vehicle. (*Statistical Abstract*, p. 619.)
- *Road construction:* In 1989, federal, state and local governments spent about $33 billion constructing, improving, and maintaining roads, streets, and highways. (*Going Rate*, p. 9.)
- *Oil imports:* According to the U.S. Department of Energy, U.S. petroleum imports increased to 42 percent of the total supply in 1990 and could reach 70 percent by the year 2010. (*Going Rate*, p. 16.) This growing dependence puts the country's national security and economic well-being at risk. In 1989 in Canada, petroleum imports were 25 percent of the total supply. (*The State of Canada's Environment*, p. 12-6.)
- *Pollution:* Motor vehicle emissions are a major source of carbon monoxide and smog. Air pollution is at unhealthy levels in many major cities of North America. Emissions of nitrogen oxides contribute to acid rain. Air pollution damages human health, buildings, crops, trees and other vegetation, and cuts visibility. Motor vehicles also pollute lakes and rivers by contributing to acid precipitation. Road runoff of salt and grease from automobiles also pollutes water, as do oil spills from oil being transported and stored, and oil improperly disposed of in sewers.
- *Global climate change:* Emissions of carbon dioxide, CFCs, hydrocarbons, nitrogen oxides, and carbon monoxide contribute directly or indirectly to global warming and ozone depletion. The buildup of carbon dioxide and other gases in the atmosphere threatens to intensify the natural warming effect that keeps the Earth habitable. CFCs, used in automobile air conditioners, contribute to ozone loss in the upper atmosphere, allowing penetration of more ultraviolet rays, which can cause skin cancers and cataracts in humans and damage plants.

U.S. motor vehicle drivers impose $300 billion in costs on society, in addition to those they pay themselves. (*The Going Rate*, p. 23.) The costs of air pollution, climate change, imports, and noise related to oil consumption amount to 50 cents for every gallon (13 cents for every liter) of gasoline and diesel fuel burned in American cars, trucks, and buses. (*Electric and Hydrogen Vehicles*)

In discussing the indirect costs of driving, encourage students to give examples. What personal experience have they had with the costs of automobile accidents? With automobile noise? With traffic congestion? Can they give examples of fields and forests that have been turned into roads and parking lots? Are there automobile graveyards and abandoned cars in or near their neighborhoods? What resources do consumers have for disposing of car batteries, used motor oil, antifreeze, and tires? Does your area suffer from air pollution? If so, how severe is the problem? Have students experienced air pollution in traveling to other areas?

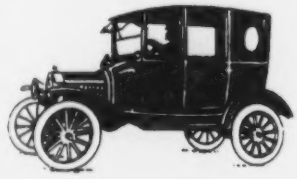
The Gulf War was a reminder of U.S. dependence on imports from the Persian Gulf. The United States government maintains a military presence in the Middle East to protect access to oil supplies, at considerable cost to taxpayers. (See *The Going Rate*, p. 17, for more information.)

The Triple Threat of Auto Emissions

As brought out in the preceding discussion, many of the hidden costs of driving are caused by auto tail pipe emissions. **Handout 4, "How Do Motor Vehicles Contribute to Air Pollution?"** is a useful summary designed to be paired with a transparency made from **Overhead Transparency Master 2, "Emissions: A Triple Threat."** These materials should help students understand why action is needed to curb emissions. If you are uncomfortable with the scientific terms and concepts in this handout, you might want to team up with a colleague from the chemistry department to present it.

Looking Back: The Road We Traveled

Before examining possible solutions to the increasingly high cost of dependence on gasoline-powered motor vehicles, use **Handouts 5A** and **5B, "The Road We Traveled,"** to examine how the gasoline-powered automobile became an integral part of American life. The handouts present a historical timeline in both written and graphic form. There are a number of options for class activities:



- Pass out both handouts. Divide students into groups to examine in depth a particular time period (e.g., the early days of cars: 1900–1920s; the decline of mass transit: 1930s–40s; the growth of the suburbs: 1950s–60s; oil shocks and dirty air: 1970s–1980s; the search for a green car: 1990s.) Have each group report briefly to the class.
- Have students develop their own timeline on newsprint or butcher paper. Alternatively, they could use computer graphics, adding details from their own research.

Looking Ahead: What's Down the Road?

Between 1970 and 1990, the number of licensed drivers in the United States increased by 50 percent. During the same period, the number of passenger cars traveling on U.S. roads grew by 61 percent; in Canada, the increase was 91 percent. Alarmingly, the use of relatively inefficient trucks and vans in the U.S. increased by 278 percent.

Also between 1970 and 1990, the number of miles the average vehicle was driven rose 11 percent in the United States, and 6 percent in Canada. Emissions of carbon dioxide from motor vehicles in the U.S. grew by 40 percent between 1970 and 1991.

Canadians report that, in metropolitan Toronto alone, cars contribute 10 million tons (9 million metric tons) of carbon dioxide annually, and the figure is projected to increase by 25 percent over the next 15 years (*The State of Canada's Environment*, p. 13-11.)

Overhead Transparency Master 3, "Number of Vehicles in the World," illustrates the projected growth in vehicle use: today's global motor fleet will probably double to 1 billion in the next 20 years.

Today, the United States and the other industrialized countries use most of the world's motor vehicles. However, nearly three quarters of the world's population live in Africa and Asia (excluding Japan). These areas currently have only 12 percent of the world's motor-vehicle registrations, but the number of motor vehicles in developing countries is expected to increase as population grows and the countries develop economically. (Show a transparency made from **Overhead Master 4, "Number of Vehicles in World Regions."**)

The largest increases in vehicle use are expected in the Asia-Pacific region (excluding Japan), Africa, the Middle East, Eastern Europe, and Latin America. (*Driving Forces*, pp. 27–28). Increasing use of motor vehicles means increasing fuel consumption, traffic congestion, air pollution, and releases of greenhouse gases, especially in these five regions. Traffic congestion is increasingly problematic in developing countries because the rate of urbanization is high. The populations of megacities such as Mexico City, Lagos, and Sao Paulo have grown much more rapidly than their transportation systems.

Air pollution caused by motor vehicle emissions is a problem not only in the regions with the most vehicles (North America, Japan, and Europe) but also in the urban areas of developing countries. Mexico City, for example, suffers from such severe air pollution—its 3 million motor vehicles contribute 80 percent of the pollutants—that it allows each car to be driven only *every other day* in an attempt to cut down on traffic. Use of leaded gas, which is damaging to human health and the environment, is common in developing countries, though it has been phased out in many industrialized countries, including the United States.

What Can Be Done

At this point in the lesson, it would be helpful to have students review both the benefits and drawbacks of a lifestyle built around automobiles.

Search for Solutions

Begin with the problem of traffic congestion. If appropriate, focus on problems familiar to students. Is there traffic congestion in your community? If so, are there any programs to encourage carpooling or vanpooling? Are there any special HOV (high-occupancy vehicle) lanes on major routes or any plans to create them?

Have students, either in small groups or as a class, brainstorm ideas for dealing with traffic congestion. After students suggest some ideas, evaluate them, asking the following questions:

- *Which are possible short-term solutions? Which are long-term solutions?*
- *Which are relatively inexpensive solutions? Which are costly?*

For example, campaigns to boost ridership on public transportation systems would be an inexpensive short-term solution; building a new mass transit system is a more expensive long-term solution. Creating a commuter network of bicycle paths might be inexpensive and relieve congestion in the short term and the long term.

Will building new roads relieve congestion? Usually, no. The cost is enormous. For example, the new "Century Freeway" being built in Los Angeles is costing about $100 million per mile ($62 million per kilometer). The Federal Highway Administration pays 92 percent of freeway construction costs. Also, new roads inevitably attract traffic and soon become congested. Most experts predict this new freeway will soon have its share of traffic jams.

Suggestions for short-term solutions might include:

- *Flexible tolls.* Tolls go up at rush hour, just as the price of a telephone call varies according to the time of day. Currently, travelers in rush hours pay indirect costs (lost time, extra gasoline) but no direct costs. Having higher tolls at rush hours might encourage people to find another way to get to work or to drive at another hour.
- *No free parking at work or school.* Nine out of ten Americans who commute to work park free. Current federal tax laws encourage businesses to subsidize employee parking. What about free parking at shopping malls? Should consumers pay for parking? Does this discourage them from driving?
- *Flexible work hours.* Employers could stagger work hours and work weeks to cut down on peak traffic hours.
- *Telecommuting.* More and more employees are working at home and using a computer to link themselves with the office.

- *Higher gasoline taxes.* During two oil embargoes, higher gasoline prices reduced the use of gasoline temporarily. Note that Americans pay half as much for gas and drive their cars twice as much as drivers in most other industrialized countries. Among the common liquids that cost more per gallon than gasoline are Coca-Cola, beer, Perrier, and pancake syrup. (*Car Trouble*, p. 89.)

Suggestions for long-term solutions might be:

- Zoning laws that discourage suburban growth and encourage growth around areas that can be served by mass transit.
- Renewing urban areas.
- Creating new, more flexible forms of mass transit. (See **Handout 8, "Taxi 2000: Personal Rapid Transit,"** discussed below.)

Next, ask students to consider the environmental damage caused by automobiles, especially air pollution, using the same process.

Three Areas for Action

Some steps that students can take are outlined in **Handout 6, "Taking Action: What Can You Do?"** Also, see WRI *Teacher's Guide* unit called *Citizen Action*. Three interesting categories for action—individual actions, legislation, and technology change—are described below.

Individual Actions

For low-impact transport:

- Walk, bike, take the bus, or subway.
- Carpool.
- If you drive, don't drive over 55 miles per hour (88 kilometers per hour), avoid rush hour, drive smoothly, buy the right gasoline, etc.
- Choose a car based on mileage, efficiency, and clean emissions.
- Maintain your car for high mileage and low emissions.

After reviewing the steps, ask students if they are willing to learn how to maintain their cars properly. (It will take some time and money.) Are they willing to change their own driving habits to use less fuel? To drive less and use other forms of transportation more?

Legislation

Certainly legislation—both state and federal—has forced auto manufacturers to reduce polluting emissions and increase fuel efficiency (the number of miles obtained from each gallon of fuel.) In most cases, the legislation was instigated by nongovernmental organizations concerned about the environment and/or the public health.

The U. S. government has set standards for air quality through the various Clean Air Act Amendments. Individual states develop policies to comply with federal laws.

California, which has the nation's most severe air pollution problem, has taken the lead in passing laws to require auto manufacturers to develop less polluting cars. In 1990, the California Air Resources Board (CARB) adopted Low Emissions Vehicle (LEV) regulations, setting progressively stricter emissions standards for cars marketed in California during the 1990s. In 1998, about 2 percent of the new cars and light trucks sold in California will have to be zero-emissions vehicles (ZEVs). By 2001, some 5 percent of the new cars and light trucks must be ZEVs; and, by 2003, 10 percent. The 12 northeastern states and the District of Columbia have committed to adopting California's LEV standards.

Technology Change

What kinds of vehicles will be developed to meet California's low- and zero-emission standards? For information about alternative fuels and new kinds of cars, give students copies of **Handout 7, "What Are The Alternatives?"** Ask students to imagine the kind of car they might be driving in 25 years.

In discussing these alternatives, point out the following:

- There is no quick and easy way to produce a new, environmentally friendly kind of car. But such a car will be produced eventually.
- Various alternatives are being explored. Some may be suitable for consumers and others for businesses. Some kinds of vehicles may be suitable mainly for short-haul urban driving.
- Solutions are being pursued by auto manufacturers and individual inventors in a variety of countries. Each year the Tour de Sol, a national electric and solar vehicle design competition, is held in the United States. The winning car in 1994, designed by students at the University of California at Davis, reached 80 miles per hour (129 kilometers per hour) and traveled 160 miles (257 kilometers) between recharges.
- Because transportation systems, vehicle types, and patterns are always evolving, someone in your class may make a significant contribution to inventing a new car, a new fuel, or a new transportation system. Creating a new mode of transportation may be one of the most significant challenges faced by this generation.

In addition to the search for cleaner cars, a variety of experiments involve improved forms of mass transit, such as high-speed trains for travel within cities. For example, **Handout 8, "Taxi 2000: Personal Rapid Transit,"** gives information about a completely new system of personal rapid transit, Taxi 2000, under development by a company in Massachusetts. The system attempts to combine the flexibility of the private car with the efficiency of a mass transit system.

Whether or not Taxi 2000 is successful, it serves as an example of the creative thinking needed to solve our transportation problems. By the year 2000, today's 15-year-olds will be out of college and joining the ranks of commuters. Ask them to envision possible futures.

Concluding the Lesson

If you wish to have a post-test, develop one from **Handout 2, "Test Yourself: How Much Do You Know About Motor Vehicle Usage?"** To develop a more extensive test, try asking students to write a variety of questions: multiple choice, short answer, or essay.

Handout 1, "Car Talk," can be used to help students analyze their driving habits. Challenge them to figure out how to reduce their driving during the next week. Make a similar plan yourself. You might ask them to fill out the questionnaire again at the end of the semester and to compare the results with the initial summary of the questionnaire to see if student driving behavior changed. (Please send us a copy of your results!)

Choose one or more of the Student Enrichment Activities to conclude the lesson, asking students to work individually or in small groups.

Audiovisual Resources

- *Running on Empty* (1988), 58 min., VHS, The Video Project. *This video traces how the automobile became the mainstay of our transportation system and also looks at the viability of alternative fuels and public transportation.*
- *Return of the Scorcher* (1992), 27 min., VHS, The Video Project. *Most of the world depends on the bicycle for basic transportation. This video asks why this method of transportation isn't more widely used in America.*
- *Moving Beyond Auto America* (1991), 28 min., VHS, The Video Project. *Featuring Ralph Nader, this video questions America's dependence on the automobile and presents alternative transportation systems already in use around the world.*
- *See page A–1 for addresses of video distributors.*

Suggestions For Further Reading

- American Automobile Manufacturer's Association (AAMA), *AAMA Motor Vehicle Facts and Figures '93* (AAMA, Detroit, Michigan, 1993).
- _____. *World Motor Vehicle Data* (AAMA, Detroit, Michigan, 1993).
- MacKenzie, J.J., and M.P. Walsh, *Driving Forces: Motor Vehicle Trends and their Implications for Global Warming, Energy Strategies, and Transportation Planning* (World Resources Institute, Washington, D.C., 1990).
- MacKenzie, J. J., *Electric and Hydrogen Vehicles: Transportation Technologies for the 21st Century* (World Resources Institute, Washington, D.C., 1994).
- MacKenzie, J. J., R.C. Dower, D. Chen, *et al., The Going Rate: What it Really Costs to Drive* (World Resources Institute, Washington, D.C., 1992).
- Ruiz, M., *et al. The History of the Automobile (Gallery Books, New York, 1985).*
- Sikorsky, R., *Car Tips for Clean Air: How to Drive and Maintain Your Car to Cut Pollution and Save Money* (Putnam, New York, 1991).
- Statistics Canada, *Human Activity and the Environment* (Statistics Canada, Ottawa, 1991).
- World Resources Institute in collaboration with the United Nations Environment Programme and the United Nation's Development Programme, *World Resources 1994–95* (Oxford University Press, New York, 1994).

1. Analyze Advertisements

Have students collect magazine and newspaper advertisements of cars. Analyze pictures and text to see how these ads appeal to the consumer. What do the ads have in common? Do they appeal to a certain age group or a certain type of buyer? What features of the automobile do they highlight? Do students note certain key words—such as quality, classic styling, luxury, beauty? How do ads for different types of cars differ? How do ads for trucks differ from ads for automobiles? As a follow-up activity, suggest that students create new ads, keeping the original pictures but rewriting the text to include some of the issues (pollution, congestion, fuel consumption) studied in the lesson. Students should keep in mind that the ads must still appeal to consumers' basic needs and desires or they won't be persuaded to buy the car.

Skills emphasis: *Science III 4, VII 2–5*

Suggested for use in: *Social Studies, English, Environmental Issues, Art*

2. Hold a Car Clinic

Sponsor a "car and drivers" clinic for students at your school. Enlist the help of knowledgeable teachers and students. Focus on steps that can be taken to promote fuel economy and reduce emissions. For example, teach participants how to check tire pressure: a car with underinflated tires uses more gas than one with its tires inflated properly. If possible, include information about places to dispose of used batteries and oil properly.

Skills emphasis: *Science III 4, VII 2–5*

Suggested for use in: *Social Studies, Environmental Issues*

3. Study Songs About Cars

Automobiles have been featured in songs, from "There's Nothing Like a Model T" to the Beatles "Drive My Car." As an individual or small-group activity, students could put together a program of popular songs about cars. Present the program to the class, with commentary. Students might also write and perform one or more original songs to include in the program. For example, one might, instead of romanticizing a car, discuss the costs; or one could describe the car of the future.

Skills emphasis: *Science III 4, VII 2–5*

Suggested for use in: *Environmental Issues, English, Social Studies, Music*

4. Shop for a Car

Have each student select the vehicle that he or she would most like to buy. Have students gather information about the vehicle by visiting auto dealers and studying ads and product information. What features of the vehicle appeal to them the most? Ask students to find out the mileage per gallon for highway and city driving for their "dream" vehicle. Then, tell them to go "shopping" by reading advertisements or visiting car dealerships for the vehicles that get the best gas mileage. How does their "dream" vehicle compare in terms of mileage? If they bought the car with the best mileage, what features would they have to sacrifice?

Skills emphasis: *Science III 4, VI 4, VII 2–5*

Suggested for use in: *Social Studies, Environmental Issues, Consumer Economics, Home Economics*

5. Stage a Public Information Campaign

Have students develop materials to educate other students. Use information in **Handout 6, "Taking Action: What Can You Do?,"** which lists specific steps for saving gas and cutting down on emissions. Posters, skits, articles in school publications, and public service announcements can be used to educate your school community and encourage individuals to take action. (See WRI *Teacher's Guide* unit on *Citizen Action* for more ideas. Available from the World Resources Institute).

Skills emphasis: *Civics V 4; Science III 4, VII 2–5*

Suggested for use in: *Environmental Issues, Social Studies, English, Journalism*

Automobile Care for the Environment

A set of four study kits, designed to be integrated into driver's education courses in grades 10 and 11, is being piloted by the Environmental Hazards Management Group, 10 Newmarket Road, P.O. Box 932, Durham, NH 03824, (603) 868-1496.

6. Map Your Community

Using maps, study your community, looking at how public transportation serves your area. If you live in a suburb, study the greater metropolitan area. Students might create a map, coloring in sections that are entirely dependent on automobiles, those that are served to a limited degree by public transportation, and those that are well served by bus, light rail, or other forms of public transportation. They can then compare the routes that are used heavily by drivers to current public transit routes to find out whether there are major gaps in public transit service. To add historical perspective, students could do research in the local public library or museum to find answers to questions such as these: Were there formerly street cars or commuter trains in their area? When were these built and put out of service? When were the suburbs built? Are there plans to add to the public transportation system?

Skills emphasis: *Geo I 1, IV 12, VI 17, 18; Hist II 4, 6, IV 5, V 2; Science III 4, VII 2–4*

Suggested for use in: *Geography, Social Studies, Environmental Issues*

7. Review Air Quality

Study what your community and your state are doing to curb or cope with air pollution. Contact your state's Department of the Environment. Does your region meet federal clean-air standards? If not, what is being planned to improve air quality? What is the state's policy on emissions testing? Under federal law, large employers in some states, such as Pennsylvania and Maryland, are being required to develop plans to reduce the number of employees who drive their cars to work alone. For information about what one state is doing, write for *Pennsylvania Cleans the Air*, published by the Department of Environmental Resources, Office of Air & Waste Management, P.O. Box 2063, Harrisburg, PA 17105, or call (717) 772-2724. For curriculum materials dealing with air pollution and air pollution testing by students, contact the Global Lab Project, TERC, 2067 Massachusetts Avenue, Cambridge, MA 02140, or call (617) 547-0430.

Skills emphasis: *Geo V 15; Science II 2, III 4, IV 2, VII 2–5*

Suggested for use in: *Geography, Social Studies, Environmental Issues*

8. Compare Alternative Means of Travel

Have each student monitor the routine trips that he or she normally makes by car. Take the same trips by other means: walking, biking, or public transportation. Compare the alternatives in terms of time, cost, and convenience.

Skills emphasis: *Geo I 8; Science VII 2–4*

Suggested for use in: *Geography, Home Economics, Social Studies*

9. Follow a Race

Each year, there is a race of electric cars, the American Tour de Sol. In 1994, the race is scheduled for a route from New York City to Philadelphia, May 21–28. Prizes are to be offered for different categories, such as commuter cars and racing cars, and for the most efficient car and the car that goes the farthest on a single battery charge. Among the entries are cars built by high school and college students. In 1993, twelve of the cars were built by high school students. For information, write the Northeast Sustainable Energy Association, 23 Ames Street, Greenfield, MA 01301, or call (413) 774-6051.

The Edison Electric Institute also sponsors a competition for electric vehicles built by high school students. Entries must be sponsored by electric utilities. For more information, contact Educational Services, Edison Electric Institute, 701 Pennsylvania Avenue, NW, Washington, D.C. 20004, or call (202) 508-5591.

On the west coast, the Portland General Electric Company sponsors the Electron Run Electric Vehicle Design and Racing Program. High schools participate in this program. For more information, write Community Resources, Portland General Electric Company, 121 S.W. Salmon Street, Portland, OR 97204. Electric go-car racing, long popular on the west coast, is spreading to the east coast. For more information, contact American Electrathon, P.O. Box 1722, Thousand Oaks, CA 91358, or call (805) 492-5858.

Skills emphasis: *Science II 9, VII 2–4*

Suggested for use in: *Environmental Issues, Vocational/Technical courses*

Car Talk

1. Do you own a car? ____ Drive a family car?_____ If yes, continue. If you do not drive a car, go to question 12.

2. Which of the following do you drive?

___ subcompact ___ compact ___ mid-size ___ large

___ minivan or small wagon ___pickup truck or large wagon

3. Model year of the vehicle you drive? 19_____

4. Other vehicles owned by you or your family:

Make _____ Model _____ Year _____

Make _____ Model _____ Year _____

5. How many miles per gallon (kilometers per liter) does your car get?

____ miles per gallon in city driving ____ miles per gallon in highway driving

(To calculate: next time you fill up your gas tank, set your trip odometer to "0." When you refill the tank, write down the trip odometer reading and the number of gallons you put in the tank. Divide the trip odometer reading by the number of gallons to calculate miles per gallon.)

6. How much do you (or your family) pay per year for—

$_____ car payments

$_____ insurance

$_____ license/registration/taxes

$_____ repairs/maintenance/tires

$_____ gas/oil

$_____ Estimated total annual cost for you to drive

7. Do you have free parking at work or school? __ yes __ no

8. How often do you carpool? ____ regularly ____ sometimes ____ never

9. Is it possible for you to take public transportation? ____ yes ____ no

10. If you have access to public transportation, how often do you use it?

____ regularly ____ sometimes ___ never

11. What factors most influenced you or your family when you bought your most current vehicle(s)? Put 1 for most important, 2 for next in importance, etc.

___Purchase price ___Safety features ___Dealership/manufacturer

___Styling ___Operating cost (mileage, etc.) ___Performance

___ Space (number of passengers, head/leg room, cargo space)

Car Talk *(continued)*

FOR DRIVERS AND NONDRIVERS

12. Log of weekly trips

Record the number of miles traveled for each purpose each day. Record the total for each day and for the week.

	Work	School	Shopping	Visit Friends	Religious, Civic or Volunteer	Pleasure	Other	Total
Mon.								
Tue.								
Wed.								
Thurs.								
Fri.								
Sat.								
Sun.								
Total:								

14. When you travel to work or school, do you travel from—

___suburb to suburb ___suburb to city ___city to suburb ___within city ___ within rural area

___other

15a. For nondrivers, how do you travel to work and/or school?

____carpool ____bus ____subway/train ____walk ____bike ___other

15b. How do you travel to other activities?

____carpool ____bus ____subway/train ____walk ____bike ____other

16. Estimate your annual transportation costs:

Drivers: Calculate your annual cost of driving by calculating your annual cost of gasoline and adding it to the total from question number 6.

Nondrivers: Calculate your annual transportation costs by multiplying your daily cost of public transportation by the number of days you use public transportation each year. If you use your bicycle for transportation, add in costs for depreciation, repairs, safety equipment, license, etc.

17. If you could buy any motor vehicle today, what would you buy? Why?

Test Yourself: How Much Do You Know About Motor Vehicle Usage?

1. What percentage of trips by United States and Canadian residents are made by private car?

___40% ___60% ___80%

2. In the United States, what percentage of all car trips are for commuting to work, school, or business-related matters?

___30% ___50% ___70%

3. How many miles each way do most U.S. commuters drive to and from work?

___5 miles (8 kilometers) ___10 miles (16 kilometers) ___25 miles (40 kilometers)

4. What percentage of Canadians walk or bike to work?

___3% ___9% ___25%

5. What percentage of U.S. commuters have free parking at work?

___15% ___50% ___90%

6. Most workers who commute by car drive from (check one):

___suburb to city ___city to city ___suburb to suburb

7. What percentage of workers in the United States commute to work by public transportation?

___5% ___20% ___60%

8. What percentage of the passenger vehicles sold in the United States today are light trucks, vans, or jeeps?

___10% ___30% ___50%

9. Since 1988, average fuel economy of new cars in the United States has:

___increased ___stayed the same ___decreased

10. Automobiles account for what percentage of the oil consumed in the United States?

___25% ___50% ___75%

11. In the United States, gasoline is

___less expensive ___more expensive ___about the same

compared with Europe and Japan.

Test Yourself: How Much Do You Know About Motor Vehicle Usage? *(continued)*

12. Since the oil embargo of 1973, is the United States:

___less dependent ___more dependent ___equally dependent

on oil from other countries?

13. In 1990, payments for imported oil accounted for what percentage of the U.S. trade deficit?

___10% ___25% ___60%

14. Older, poorly maintained cars make up 10% of the cars in the United States, but they account for what percent of all emissions?

___10% ___50% ___90%

15. Which human activity is the largest contributor to air pollution?

___industry ___motor vehicle use ___the worldwide burning of forests

16. More land in the United States is used for roads, driveways, parking lots, and garages than is used for housing.

___True ___False

17. The three United States cities with the worst traffic congestion are:

___Los Angeles, New York, and Chicago

___San Francisco, Los Angeles, and Washington, D.C. ___Miami, Los Angeles, and Detroit

18. The number of motor vehicles in the United States are increasing at:

___about the same rate as the population ___twice the rate of population growth

___three times the rate of population growth

19. Per capita, United States residents are driving:

___more miles each year ___fewer miles each year ___same as previous years

20. Compared with drivers from other industrialized countries, the average United States resident drives:

___twice as many miles per year ___three times as many per year

___the same number of miles per year

21. What percentage of all the automobiles in the world are in the United States (tip: the United States has 5 percent of the world's population)?

___9% ___34% ___65%

Answers to "How Much Do You Know About Motor Vehicle Usage?"

1. Eighty-two percent of all trips are by motor vehicle.

2. Over 70 percent of car trips are business related.

3. Half of all trips to and from work are five miles or less each way.

4. Nine percent of Canadians bike or walk to work.

5. Ninety percent of commuters in the United States have free parking at work. The availability of free parking encourages solo commuting.

6. Only 10 percent commute from suburb to city. About 40 percent of all commutes are suburb to suburb; 33 percent are city to city.

7. Less than 5 percent of United States workers use public transportation to commute to work. Eleven percent of Canadian workers use public transportation.

8. Twenty percent of United States residents are driving light trucks, vans, or jeeps—which, on average, get only 21 miles per gallon (9 kilometers per liter), compared to 28 miles per gallon (12 kilometers per liter) for a new car.

9. From 1988 to 1992, fuel economy declined by 4 percent because Americans were buying bigger, more powerful cars and choosing options that reduce fuel efficiency, such as air conditioning, power accessories, and four-wheel drive.

10. Two thirds of the oil used in the United States goes for transportation; half is used to power automobiles.

11. Gas costs less in the United States than in Europe or Japan. The cost of gas in the United States is about one third the cost of gas in Japan and Europe.

12. Since the oil embargo of 1973, the amount of oil imported from the Persian Gulf has more than doubled. The United States imports 42 percent of its oil from other countries, leaving it vulnerable to interruptions in supply and price increases.

13. In 1990, payments for imported oil accounted for 60 percent of the nation's trade deficit.

14. According to the United States Environmental Protection Agency, older, poorly maintained cars make up 10 percent of automobiles in the United States but account for half of all auto emissions. Clean air regulations pertain almost exclusively to new cars, and inspection and maintenance programs to reduce pollution contributed by cars already on the road have not been effective.

15. Motor vehicles cause more air pollution than any other single human activity. In its lifetime, a typical new car equipped with pollution-control devices will emit some 300 pounds (136 kilograms) of smog-forming compounds and 34 tons (30.8 metric tons) of carbon dioxide. Emissions of carbon dioxide, CFCs, hydrocarbons, nitrogen oxides, and carbon monoxide contribute to global warming and ozone depletion.

16. True. About 2 percent—60,000 square miles (155,400 square kilometers), an area larger than Nicaragua—of the total surface area of the United States has been paved over.

Answers to "How Much Do You Know About Motor Vehicle Usage?" *(continued)*

17. The top three are Los Angeles, San Francisco, and Washington, D.C. Others in the top ten are Chicago, Miami, Seattle, Houston, San Diego, Boston, and tied for tenth, New York and Atlanta.

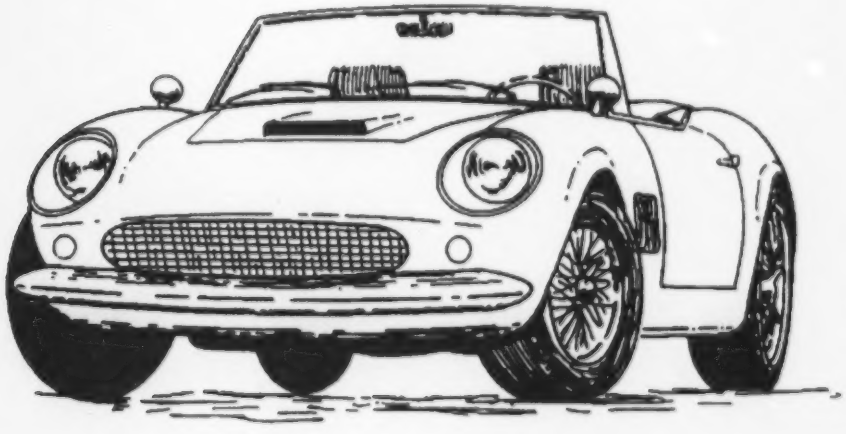
18. The numbers of motor vehicles are growing more than three times faster than population is growing in the United States. Between 1970 and 1990, the U.S. population increased 23 percent, while motor vehicles on the road increased by 75 percent. (Passenger cars alone increased by 61 percent.)

19. More. During 1980–89 in the U.S., the number of miles driven per vehicle grew by 16 percent, and total miles traveled rose by more than 40 percent. Total distance driven increased by 22 percent during the same period in Canada.

20. Twice as many. The average U.S. resident drives or rides 12,500 miles per year (20,112 kilometers per year) in cars and light trucks, almost double the distance traveled in most other industrial countries. No other country in the world depends as heavily on motor vehicles as the United States does.

21. Although the United States has only 5 percent of the world's population, it contains 34 percent of the world's motor vehicles and consumes 26 percent of the world's oil.

Sources: American Automobile Manufacturers Association (AAMA), *AAMA Motor Vehicle Facts and Figures '93* (AAMA, Detroit, Michigan, 1993); and Nadis, Steve and James J. MacKenzie, *Car Trouble* (World Resources Institute, Washington, D.C., 1993).



How Do Motor Vehicles Contribute to Air Pollution?

Gasoline-powered motor vehicles release the following pollutants into the air:

- **Carbon monoxide (CO).** Motor vehicles contribute about 53 percent of carbon monoxide in the United States. (In Canada, it is about 55 percent.) CO contributes to ozone formation. When inhaled, it can interfere with the body's ability to carry oxygen in the bloodstream.
- **Nitrogen Oxides (NOx).** Motor vehicles contribute about 30 percent of nitrogen oxides released in the United States. (In Canada, about 50 percent.) NOx contribute to acid precipitation and smog; health effects include stinging eyes, coughing, increased asthma attacks, and greater susceptibility to infection. Nitrogen oxides are toxic to plants.
- **Volatile Organic Compounds (VOCs).** Motor vehicles contribute an estimated 27 percent of VOC emissions in the United States. (In Canada, about 35 percent.) VOCs combine with NOx to form smog. Health effects include eye irritation, respiratory irritation, and even cancer.
- **Lead.** Airborne lead particulates. Leaded gasoline is sold in Mexico and most other developing countries, but is no longer available in the United States and Canada. Lead causes circulatory, reproductive, nerve, and kidney damage and learning problems. Children are especially susceptible.
- **Particulates.** Microscopic particles in auto exhaust enter the lungs and contribute to respiratory disease.
- **Smog (tropospheric ozone).** In the lower atmosphere, ozone is a pollutant formed when NOx reacts with VOCs in the presence of sunlight. Ozone can cause respiratory problems in humans and damage to vegetation. Motor vehicles are the dominant source of emissions of carbon monoxide, oxides of nitrogen, and volatile organic compounds in industrialized countries.

HOW DO MOTOR VEHICLES CONTRIBUTE TO GREENHOUSE GASES?

Carbon dioxide, water vapor, methane, and other gases create the insulating or "greenhouse effect" of the atmosphere. These gases prevent some of the Earth's solar heat from escaping into space so the planet stays warm enough for life to exist. However, human activities—especially burning fossil fuels—has increased the level of greenhouse gases in the atmosphere, and, as a result, is expected to cause additional overall global warming.

Motor vehicles account for about 25 percent of U.S. carbon dioxide emissions. (In Canada, about 23 percent.) For every gallon of gasoline consumed by an automobile, about 19 pounds (2.3 kilograms per liter) of carbon dioxide are emitted. In a year, the typical American car pumps almost 5 tons (4.5 metric tons) of carbon dioxide into the atmosphere. (*Car Trouble*, p. 27.)

(For more information on climate change, see the WRI *Teacher's Guide* unit *Energy, Atmosphere, and Climate*.)

WHY IS THERE CONCERN ABOUT INCREASED GREENHOUSE GASES?

Atmospheric concentrations of greenhouse gases are rising at unprecedented rates. Carbon dioxide emissions from developing countries are expected to increase rapidly as the numbers of motor vehicles grow in these countries. If today's trend in carbon dioxide emissions continues, motor vehicle emissions will increase by 50 percent by the year 2010.

How Do Motor Vehicles Contribute to Air Pollution? *(continued)*

WHY IS THERE CONCERN ABOUT "GLOBAL WARMING?"

Global warming is expected to persist for centuries. Although exact effects are not known, it is believed that climate change would affect the following:

- **Health.** Tropical, mosquito-borne diseases, such as malaria, dengue fever, and yellow fever, might spread to a wider area. Heat-related illnesses would increase.
- **Agriculture.** The growing season in areas of the Northern hemisphere, such as Finland, Japan, Iceland, and Canada, would be lengthened. However, temperate bread basket areas such as those in the United States and Canada would be dryer.
- **Forests.** Parasites from the tropics might extend their range and attack temperate forests. Some temperate tree species might become locally extinct.
- **Rangelands.** An ongoing decline in productivity from drought and erosion would intensify. The number and range of fires would grow.
- **Wildlife**. Many species would become extinct because their habitat would shift, shrink, or disappear.
- **Oceans.** Locations of currents and fisheries could change. Rising sea levels could flood coastal areas and threaten low-lying countries, such as Bangladesh.
- **Islands.** Low-lying island states in the Caribbean, the Pacific, the Indian Ocean, and elsewhere could disappear if sea levels rise.
- **Storms.** Because tropical storms and hurricanes derive their heat from oceans, they could increase in intensity as the ocean warms. Severe storms and storm surges, protracted hot spells and droughts, early frosts and long cold snaps might all occur more often in response to global warming.

HOW DO MOTOR VEHICLES CONTRIBUTE TO OZONE LOSS?

In the upper atmosphere, ozone absorbs much of the sun's damaging ultraviolet rays. Air conditioners in motor vehicles release chlorofluorocarbons (CFCs) that rise up to the upper atmosphere or stratosphere, 9 to 30 miles (14.5 to 48 kilometers) above the Earth's surface. One CFC molecule can destroy as many as 100,000 ozone molecules.

Ozone losses in the upper atmosphere are occurring at all latitudes in both hemispheres. A striking example of ozone loss has been recorded over the South Pole during September and October in recent years. Significant ozone losses have also been found at mid-latitudes (45° corresponds to Christchurch, New Zealand in the south and Minneapolis, Minnesota in the north.) There are also indications that another ozone hole exists over the North Pole.

WHY IS THERE CONCERN OVER OZONE LOSS?

The ozone layer is a protective shield. As ozone is lost, more biologically harmful ultraviolet-B (UV-B) radiation will reach the Earth. Skin cancer rates are expected to increase. Other health effects will probably include an increase in cataracts and suppression of the immune system. Increased UV-B radiation may also affect marine life and damage crops and plant species. Scientists are currently investigating whether there could be a link between increased radiation and the worldwide decline in frogs and other species of amphibians, as reported in the *New York Times,* March 1, 1994.

The United States and other countries have signed an international agreement to phase out CFCs. However, CFCs already released will go on destroying ozone for de:ades.

Sources: *Car Trouble* and *Teacher's Guide to World Resources 1992–93.*

The Road We Traveled

When first introduced, automobiles offered a flexibility and freedom that no other means of transportation could provide. Gasoline-powered vehicles soon became dominant because the price of oil was low and the supply seemed unlimited.

- During the first automobile boom, between 1895 and 1908, France dominated the automobile industry.
- The most important date of all may be 1908, the year of the introduction of the Model T Ford, which sold for $825 and was intended to be "a car for the great multitude." (*Car Trouble*, p. 3.) By 1913, Ford was the world's leading auto manufacturer, and by 1916, assembly line production brought the price of the Model T down to $360 so the middle class could afford it. (*Revolution*, p. 84.)
- Until World War I, more than one third of the motor vehicles in the United States were electric. The restricted driving range of electric cars was not a problem then because most driving was done in cities; the terrible condition of country roads discouraged automobile traffic. Before the electric self-starter was invented, hand-cranking a gasoline engine was difficult and dangerous. Electric cars, which were safer and easier to start, were especially favored by women drivers.
- The first gasoline-powered vehicle with an electric starter was the 1911 Cadillac. This new electric invention ironically meant that electric cars were superseded by gasoline-powered vehicles. Cars with internal combustion engines could go farther and faster; their engines could be made in all sizes.
- Cars became the principal means of travel during the 1920s. By 1930, there were twice as many paved roads as there had been a decade earlier. In 1927, in the United States, there was one car for every 5.3 inhabitants; in Canada, the figure was one for every 10.5 people. (In comparison, there is now one car for every 1.7 people in the United States, and one car for every 2.1 people in Canada. The current numbers of people per car in some other countries are: Japan, 2.1; U.K., 5.3; France, 2.0; Mexico 8.4; Brazil, 12; India, 356; Uganda, 1,453.
- During the 1920s, Canada became the second largest producer of automobiles. The United States continued to be the leading producer; General Motors surpassed Ford as the largest manufacturer. (*Revolution*, pp. 91 and 101.)
- By the end of the 1920s, some 55 percent of American families owned a car (*Revolution*, p. 112.). Car buyers had begun to buy on credit on the installment plan. Car manufacturers began to change models each year and to emphasize styling changes. They became the largest advertisers, creating consumer demand for newer products that boasted increased comfort, style, and power. It was an automaker, Louis Renault, who said that "To live is to consume." (*Revolution*, p. 117.)
- In the 1920s, the automobile was changing the lifestyle in the United States and Canada. Rural areas especially benefited because they were no longer isolated. The U.S. Post Office began free rural delivery. Farm children went to larger schools by car or school bus. Automobiles changed life for city dwellers, too, encouraging the growth of suburbs. People used their cars to drive to work and to go shopping. They took Sunday drives on weekends and drove to national parks and resorts for their vacations. (*Revolution*, p. 114–116.)

The Road We Traveled *(continued)*

- During the 1930s, 1940s, and 1950s, automakers, tire manufacturers, oil companies, and construction industries worked to dismantle mass transportation systems and replace them with automobiles. The National City Lines, a company backed by General Motors, Standard Oil, Phillips Petroleum, Firestone Tire and Rubber, Mack Truck, and other auto interests bought up and closed down more than 100 electric trolley lines in 45 cities. In 1949, GM and the other companies were convicted of conspiring to replace electric transportation systems with buses and to monopolize the sale of buses. (*Car Trouble*, p. 5.)

- Henry Ford encouraged Americans to abandon city slums for the suburbs. State and federal policies encouraged road-building and housing construction in outlying suburbs. Through tax laws, the federal government has encouraged home ownership and single-family housing and has encouraged builders to create new structures rather than renovate old ones. While there were advantages—privacy, open space, quiet—there were also disadvantages. Suburbs are often "transit unfriendly;" suburbanites who must depend on the automobile encounter gridlock as they commute to jobs in the city or in other suburbs.

- In 1956, the Interstate Highway Act committed the federal government to build 44,000 miles (70,796 kilometers) of toll-free express highways. It created the Highway Trust Fund, derived mainly from taxes on cars, gas, tires, and auto parts.

- Beginning in the 1960s, because of the increasingly large numbers of automobiles concentrated in urban areas, the social costs of automobiles began to be recognized in the industrialized countries, according to Jean-Jacques Chanaron, a French historian. In cities, automobiles created traffic, noise, and accident-related problems, and they contributed to air pollution.

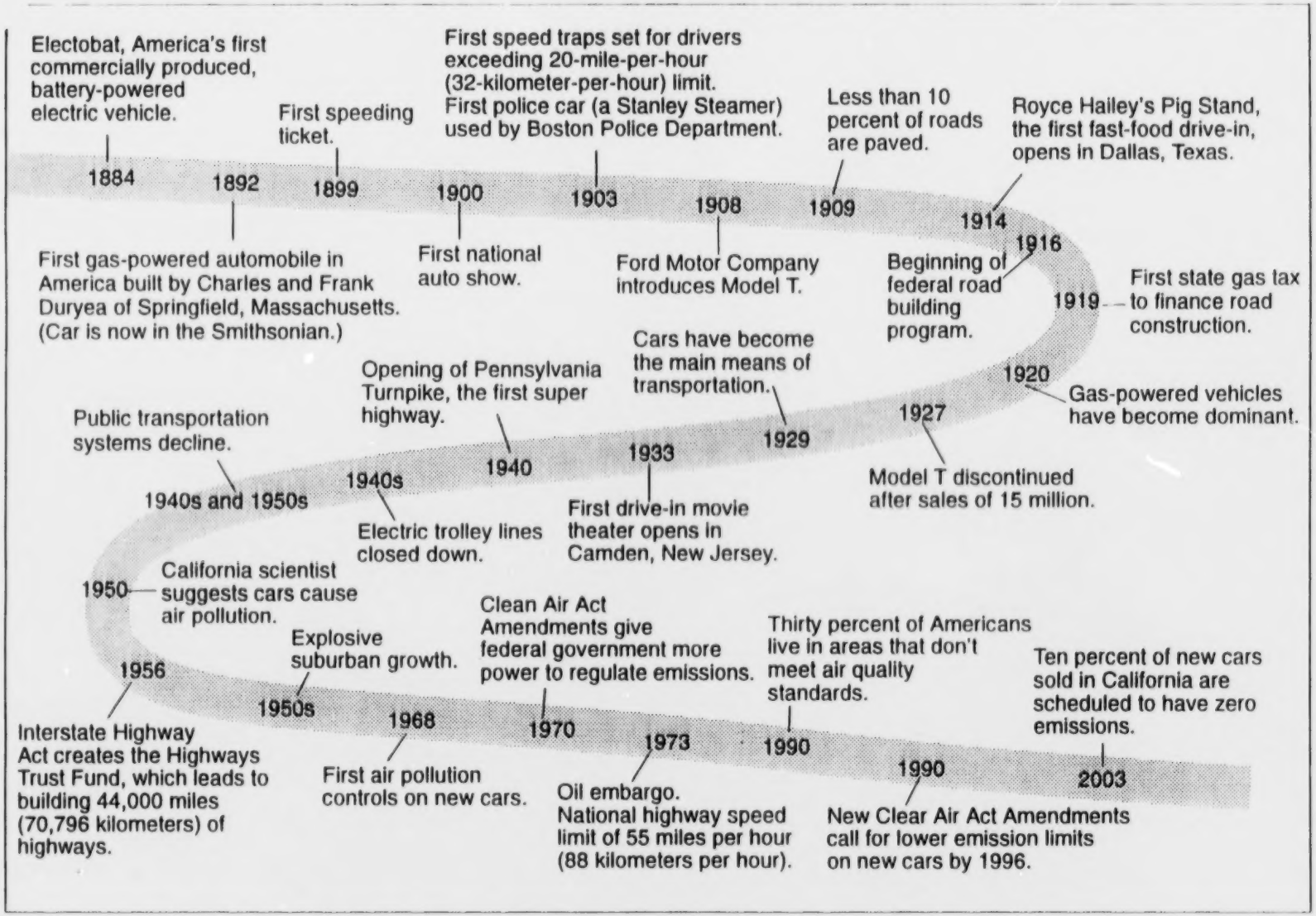
- The Arab oil embargo, imposed by OPEC producers in 1973, restricted the supply of oil temporarily and caused prices to rise. The embargo led to new energy policies, including a 55 mile-per-hour (88 kilometer-per-hour) speed limit, mandatory fuel-efficiency standards for automobiles, the trans-Alaska oil pipeline, and a national campaign to cut energy use. President Nixon in 1973 stressed the importance of developing energy independence to end reliance on imported oil. However, the United States imports an increasing percentage of its oil: 42 percent in 1990, up from 27 percent in 1985. (*Car Trouble*, p. 17.)

- The 1973 oil embargo also sparked renewed interest in electric-powered vehicles. The Electric and Hybrid Vehicle Research, Development, and Demonstration Act was passed to stimulate research and testing. Subsequently, the 1978 Solar Photovoltaic Research, Development, and Demonstration Act called for the commercialization of photovoltaic technology. (*Car Trouble*, p. 181.)

- The 1970s saw the beginning of federal "clean air" legislation. The Clean Air Act Amendments of 1970 established National Ambient Air Quality Standards and gave the federal government more power to regulate pollution sources. The 1977 Clean Air Act Amendments mandated a 96-percent reduction in hydrocarbons and carbon monoxide and a 75-percent reduction in nitrogen oxides from cars (relative to cars with no controls) (*Car Trouble*, p. 181.). The 1990 Clean Air Act Amendments set even stricter standards to lower emissions of hydrocarbons (by 40 percent) and nitrogen oxides (by 60 percent) by 1996; regulated emission from trains, boats, and other sources; required gas pumps to have attachments to capture vapors; and set a schedule for increasingly strict emission standards for new cars to be phased in over 10 years.

Sources: Nadis, Steve and James J. MacKenzie, *Car Trouble* (World Resources Institute, Washington, D.C., 1993) and Bardou, Jean-Pierre, *et al.*, *The Automobile Revolution: The Impact of an Industry* (The University of North Carolina Press, Chapel Hill, NC, 1982).

The Road We Traveled: Graphic Timeline


Electobat, America's first commercially produced, battery-powered electric vehicle.
1884
1892
First gas-powered automobile in America built by Charles and Frank Duryea of Springfield, Massachusetts. (Car is now in the Smithsonian.)
First speeding ticket.
1899
First speed traps set for drivers exceeding 20-mile-per-hour (32-kilometer-per-hour) limit.
First police car (a Stanley Steamer) used by Boston Police Department.
1900
First national auto show.
1903
1908
Ford Motor Company introduces Model T.
Less than 10 percent of roads are paved.
1909
Royce Hailey's Pig Stand, the first fast-food drive-in, opens in Dallas, Texas.
1914
1916
Beginning of federal road building program.
1919
First state gas tax to finance road construction.
1920
Gas-powered vehicles have become dominant.
1927
Model T discontinued after sales of 15 million.
Cars have become the main means of transportation.
1929
Opening of Pennsylvania Turnpike, the first super highway.
1933
First drive-in movie theater opens in Camden, New Jersey.
1940
Public transportation systems decline.
1940s and 1950s
1940s
Electric trolley lines closed down.
1950
California scientist suggests cars cause air pollution.
1956
Interstate Highway Act creates the Highways Trust Fund, which leads to building 44,000 miles (70,796 kilometers) of highways.
Explosive suburban growth.
1950s
1968
First air pollution controls on new cars.
Clean Air Act Amendments give federal government more power to regulate emissions.
1970
1973
Oil embargo.
National highway speed limit of 55 miles per hour (88 kilometers per hour).
Thirty percent of Americans live in areas that don't meet air quality standards.
1990
1990
New Clear Air Act Amendments call for lower emission limits on new cars by 1996.
Ten percent of new cars sold in California are scheduled to have zero emissions.
2003

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35

Taking Action: What Can You Do?

When You Buy a Car...

- Shop for fuel efficiency. Try to buy a car that gets at least 35 miles per gallon (15 kilometers per liter). Think twice about buying a light truck because these need more fuel than the average new car.
- Choose accessories carefully. Options such as power steering and automatic transmissions require energy and reduce fuel economy. Radial tires improve gas mileage because they roll with less friction.

When You Drive...

- Observe speed limits.
- Accelerate and decelerate smoothly.
- Don't let the engine idle for more than one minute. Idling wastes fuel and contributes to air pollution.
- Don't brake more than is necessary. Braking wastes fuel.
- Combine errands into one trip.
- Avoid rush-hour travel if possible. Idling and stop-and-go driving waste fuel.
- If you have a choice of vehicles, choose the more fuel-efficient one.
- Give a ride to a friend or carpool.
- Don't always drive: walk, bike, or use public transportation when possible.

When You Maintain Your Car...

- Keep the engine tuned up to maximize gas mileage and minimize emissions.
- Inspect and replace filters regularly. Clogged filters can mean wasted gasoline and higher emissions.
- Don't "top off" the gas tank. Extra gas mostly evaporates, adding to ground-level pollution.
- Use the gas with the minimum octane needed for your car. Check your car's owners' manual. Only cars with turbocharged, high-performance engines need premium, high-test fuel.
- Use the motor oil recommended for your car. Some types of oil contain additives that increase fuel economy.
- Keep tires inflated properly. Fuel economy drops 1 percent for every pound of pressure below the recommended level.
- Recycle old tires and batteries.
- Have your air conditioner serviced by a trained mechanic with access to a "vampire" machine, which recycles freon. These machines drain the coolant, purify it, and reinject it into the air conditioner. Fix leaks.

Source: Steve Nadis and James J. MacKenzie, *Car Trouble* (World Resources Institute, Washington, D.C., 1992). For additional suggestions, see Robert Sikorsky's *Car Tips for Clean Air: How to Drive and Maintain Your Car to Cut Pollution and Save Money* (Putnam, New York, 1991).

What Are the Alternatives?

Alternative Fuels Now Available

Carbon-Based Fuels

Reformulated or "clean" gasolines are special blends of gasoline designed to reduce emissions.

Where used: In California, beginning in 1989. By 1995, these must be sold in eight Northeastern and mid-Atlantic states and the District of Columbia.

Advantages: Any car can use them, and they can be distributed by existing gas stations. Their use helps reduce emissions of carbon monoxide and ozone-forming compounds.

Disadvantages: These are not a long-term solution and their use does nothing to curb dependence on imported oil. They contain the same amount of carbon as regular gasoline.

Methanol or "Wood Alcohol"

A liquid fuel made from natural gas, wood, or coal.

Where used: Race cars have used it since 1965 in the Indy 500. Demonstration vehicles have been developed by major auto companies.

Advantages: A liquid fuel, comparable in price to gasoline, it can be used in modified gas engines.

Disadvantages: Gallon for gallon, it has only half the energy of gasoline and it is only slightly "cleaner" than regular gasoline. Cars fueled with pure methanol are hard to start in cold weather. Distribution problems arise because it is toxic and highly corrosive. Environmental benefits depend on how it is made: production from coal is a "dirty" process. And it releases more greenhouse gases than regular gasoline.

(continued)

Cars of the Future

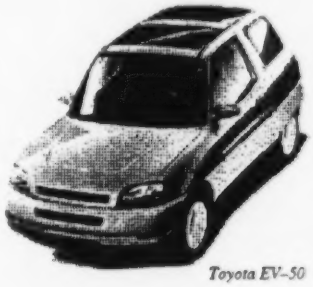
Electric Vehicles

Vehicle whose wheels are powered by electric motors. Electricity comes from an on-board electric source, such as batteries, hydrogen-powered fuel cells, flywheels, ultracapacitors—or some combination of these. Some electric cars have solar cells mounted on them to provide a small part of their energy. The batteries are recharged periodically at home or at recharging stations using power produced by electric power plants.

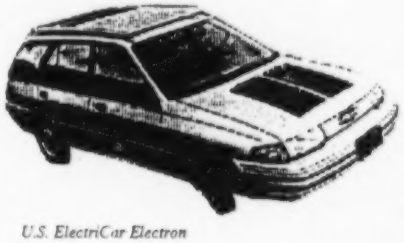
Where used: Some are used in other countries. Prototypes are being tested by the major U.S. auto manufacturers around the world.

Advantages: Zero tail-pipe emissions! Electric vehicles would significantly improve urban air quality. They are closer to commercial readiness than hydrogen-fueled vehicles. They could be powered from domestic energy sources rather than imported oil, and there are enough power plants available to fuel large numbers of electric cars. How much they contribute to air pollution and global warming depends on the type of fuel used at the power plants that generate the electricity.

Disadvantages: Currently, electric vehicles cost more than gasoline vehicles to buy and operate. An electric vehicle could increase a family's electricity consumption by 22 to 55 percent. Most EVs use lead-acid batteries, which are heavy, have relatively short lifetimes, and require maintenance. It is still difficult to store enough energy in these batteries for long trips, so electric vehicles have a limited range—100 miles (161 kilometers) or less—before their batteries must be recharged. EVs require a system of recharging facilities, battery-recycling centers, and other equipment.



Toyota EV-50



U.S. ElectriCar Electron

Solar Vehicles

Solar vehicles are experimental electric vehicles that derive some of their power from the sun.

Where used: Primarily in special races of similar vehicles.

Advantages: The same as with electric cars. An additional advantage is that they do not require electricity from a power plant.

Disadvantages: They are currently expensive to build. It is difficult to find the space on a car for enough solar cells to provide adequate power, hence they have a limited range.

What Are the Alternatives? *(continued)*

Alternative Fuels Now Available

Ethanol or "Grain Alcohol"

A liquid fuel made from organic matter or biomass such as sugar cane or corn.

Where used: In the United States, it is mixed with gasoline—one part ethanol to nine parts gasoline—to make "gasohol." Production is subsidized by federal and state governments. In Brazil, pure ethanol fuel is used.

Advantages: Ethanol can be made from solid waste or leftover organic material. It reduces carbon monoxide emissions.

Disadvantages: Ethanol costs twice as much as gasoline but has only two thirds the energy content. It's not feasible to raise the amount of corn required to produce it. Using ethanol would not significantly curb the release of greenhouse gases. It may increase smog in the summer.

Compressed Natural Gas (CNG)

Where used: This fuel is in limited use in the United States. More than half a million CNG vehicles are on the road, mostly in Italy, New Zealand, Canada, and the former Soviet Union.

Advantages: CNG costs half as much as premium gas. CNG is a comparatively clean fuel—containing much less carbon monoxide and fewer hydrocarbons. Almost no toxic and carcinogenic pollutants are emitted. Greenhouse gas emissions would be slightly lower with this fuel than with gasoline.

Disadvantages: CNG vehicles are more expensive to build and have a shorter range between fuel stops than gas-powered ones. Because the fuel needs bulky storage tanks, it may be better suited to buses and trucks. It is difficult to distribute and requires expensive high-pressure gas compressors for refueling. Most natural gas used in the United States is imported from Canada.

Cars of the Future

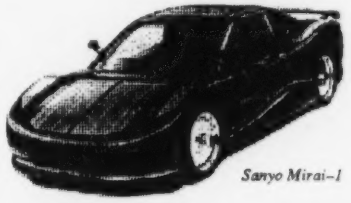
Hybrid Vehicles

Vehicles containing two propulsion systems: for example, one battery-powered electric motor and one internal-combustion engine using gasoline or a similar fuel.

Where used: None widely available. Different kinds of hybrids are under development worldwide. General Motors and Ford Motor Company are developing hybrids over the next five years with support from the U.S. Department of Energy.

Advantages: The vehicles get better fuel economy and lower emissions than gasoline-powered vehicles. They also have a greater range than electric vehicles. They could serve as transitional vehicles until more powerful batteries are developed.

Disadvantages: Because of their dual systems, they are more expensive and complicated to build than either a battery-powered or an internal combustion car.



Sanyo Mirai-1

Hydrogen-Powered Vehicles

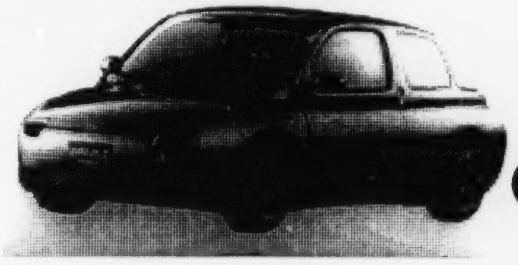
These vehicles are powered by hydrogen—a gas made from natural gas or coal, or better yet from water using the simple process of electrolysis. The cheapest current source of hydrogen is natural gas.

Where used: Only in test vehicles so far. Prototypes are under development in Europe, Japan, and the United States.

Advantages: Hydrogen is an abundant element. Hydrogen fuels could reduce or eliminate the need for imported oil. Hydrogen-fueled vehicles would have no emissions of greenhouse gases and only small amounts of nitrogen oxides. In the long term, fuel cells, rather than internal combustion engines, would power the vehicles.

Disadvantages: Hydrogen is difficult to distribute, store, and handle. A major hurdle is figuring out how to store enough compressed hydrogen gas in a car to give it an acceptable range. If hydrogen becomes the fuel of the future, a distribution system like the current network of gasoline stations might have to be built.

Mazda HR-X2



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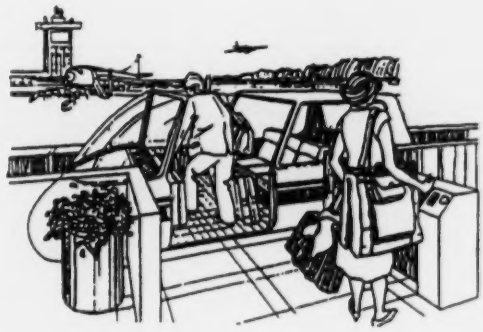
Taxi 2000: Personal Rapid Transit

Taxi 2000 is a personal rapid transit system being built at a test facility in Marlborough, Massachusetts, by the Raytheon Company. The concept of personal rapid transit originated in the 1950s in response to increasing congestion and air pollution in urban areas. Personal rapid transit has been studied ever since, but has never been put into practice.



Unlike regular mass transit, in which many passengers share a bus or rail car, personal rapid transit systems allow passengers to ride in computer-controlled, three-passenger vehicles that move along guideways 16 feet (5 meters) above ground. Passengers can ride their car non-stop, direct to any station in the network, without transferring.

When passengers enter the station, they consult a map of the system and buy their ticket from a machine. The fare is per vehicle, not per person. One, two, or three people may ride together by choice. Passengers never have to ride with strangers if they don't want to. The passengers then go to the first empty vehicle, insert the ticket into a slot, give their destination to the microprocessor aboard the vehicle, seat themselves, and press a go button. The vehicle automatically moves out and merges into the stream of traffic going by the station. When the vehicle reaches the specified destination, it pulls into a berth, and the passengers exit the vehicle. The system is designed to be fully accessible to all people, including handicapped patrons.

There is no waiting time during off-peak hours. During rush hour, about 60 percent of passengers wait less than 30 seconds, and 90 percent less than 3 minutes. Since passengers go directly to their destination, they do not lose time stopping at other stations.

Taxi 2000 vehicles are much quieter than automobiles. They run on smooth tires on smooth steel rails. Since the system uses electric power, air pollution is reduced. The only emissions come from the electric power plant.

To build the Taxi 2000 system, posts must be erected along existing roadways and the elevated guideways constructed a quarter to a half mile apart. Stations must be constructed about a quarter of a mile apart to be convenient for patrons. Some stations will be built in existing buildings. Thus, the only land required is for posts and stations. The building costs are estimated to be about $10 million a mile ($9 million per kilometer)—one tenth the cost of building a heavy rail system. If the prototype Personal Rapid Transit system in Marlborough succeeds, the first people-moving demonstration is planned for Rosemont, Illinois, a suburb of Chicago.

Questions

1. How does the Taxi 2000 system differ from mass transit systems that you have used?

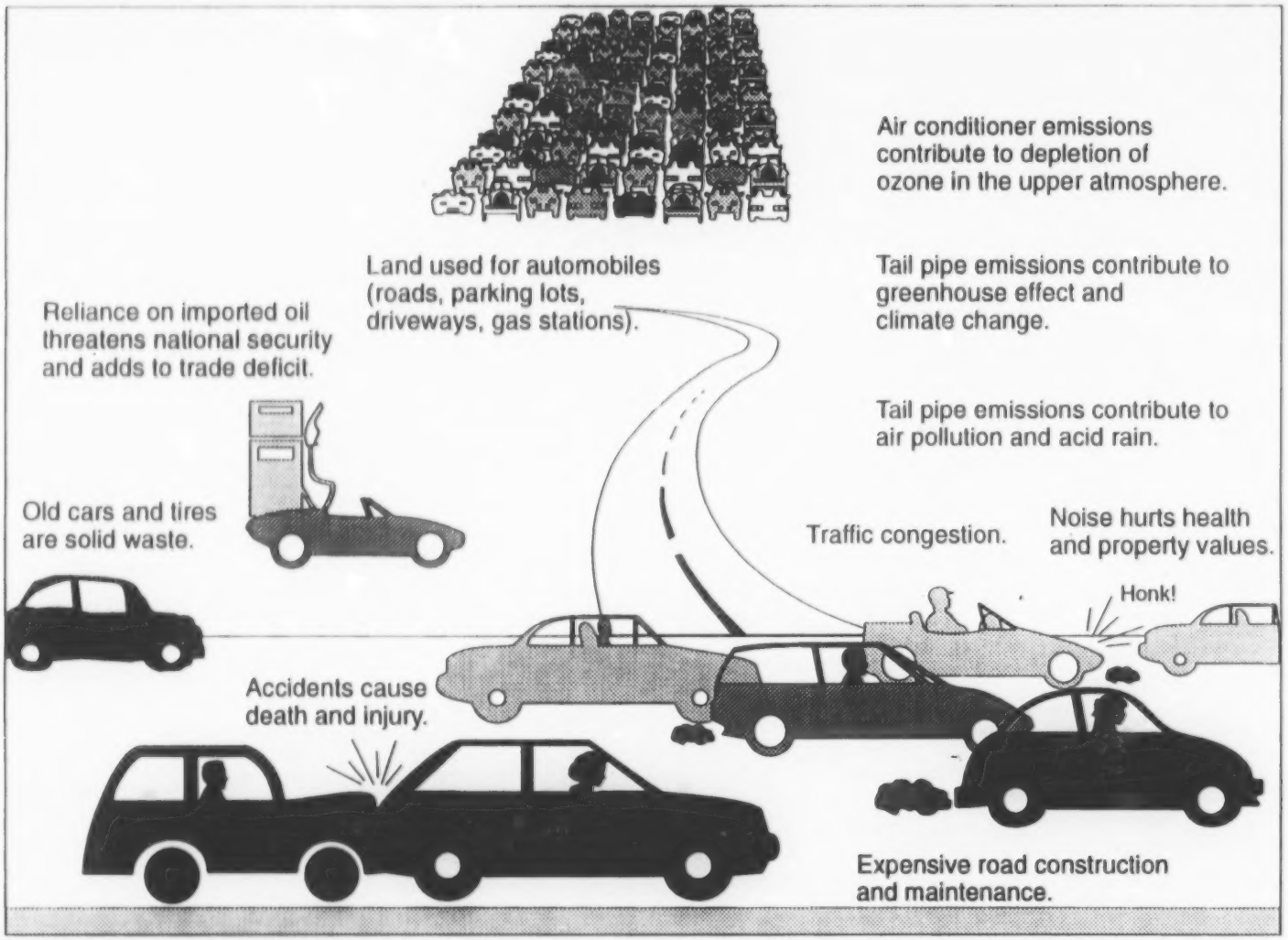
2. What are some advantages of Taxi 2000? Can you think of any disadvantages?

3. Would a personal rapid transit system be appropriate for your community? If so, using a map, plan a network of guideways and stations.

4. Can you think of other new modes of transportation for the future that might address some of the problems raised in this lesson?

40

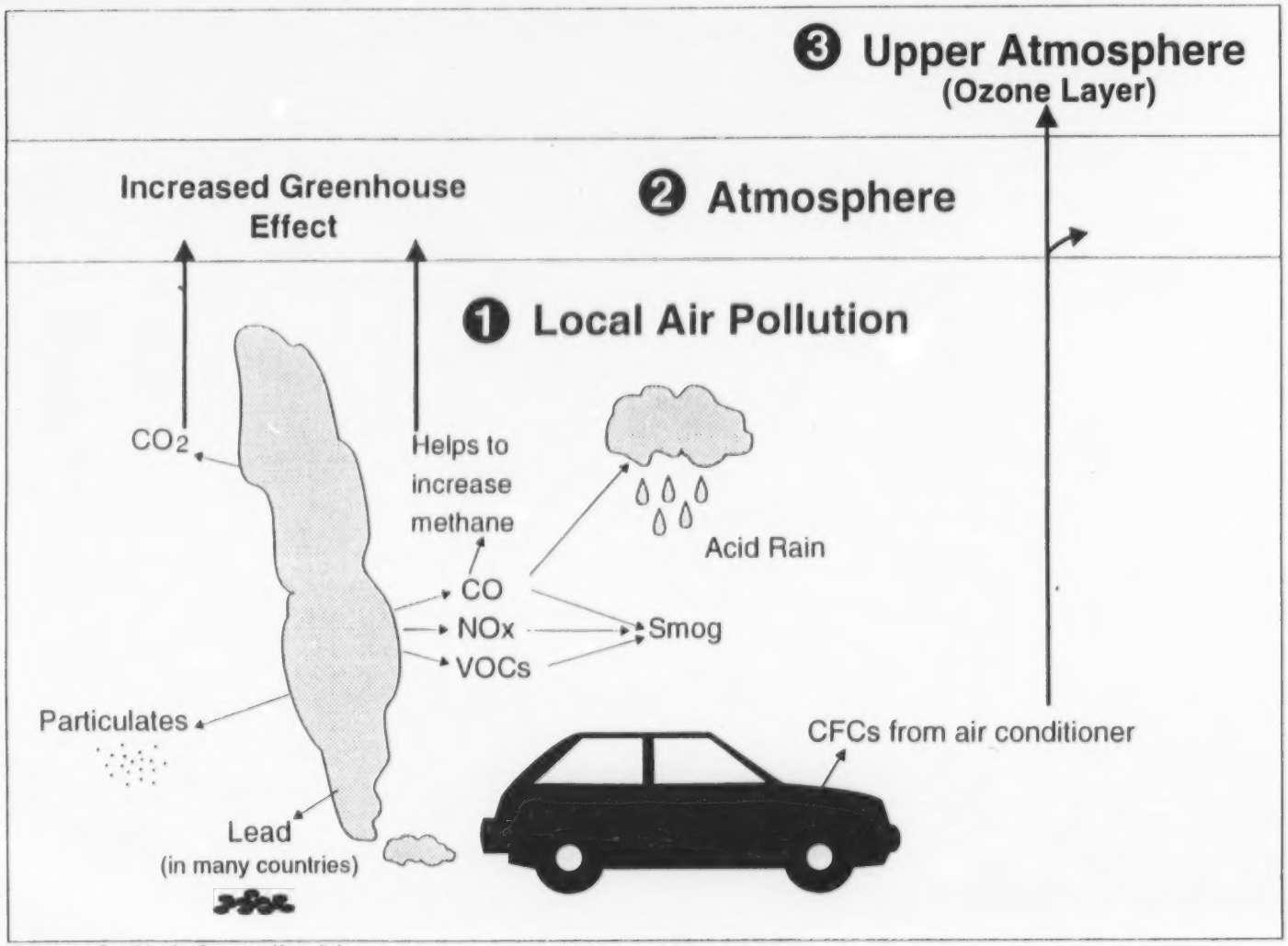
The Hidden Costs of Driving


Air conditioner emissions contribute to depletion of ozone in the upper atmosphere.
Land used for automobiles (roads, parking lots, driveways, gas stations).
Tail pipe emissions contribute to greenhouse effect and climate change.
Reliance on imported oil threatens national security and adds to trade deficit.
Tail pipe emissions contribute to air pollution and acid rain.
Old cars and tires are solid waste.
Traffic congestion.
Noise hurts health and property values.
Honk!
Accidents cause death and injury.
Expensive road construction and maintenance.

Computer Graphics by Susanne Kamalieh

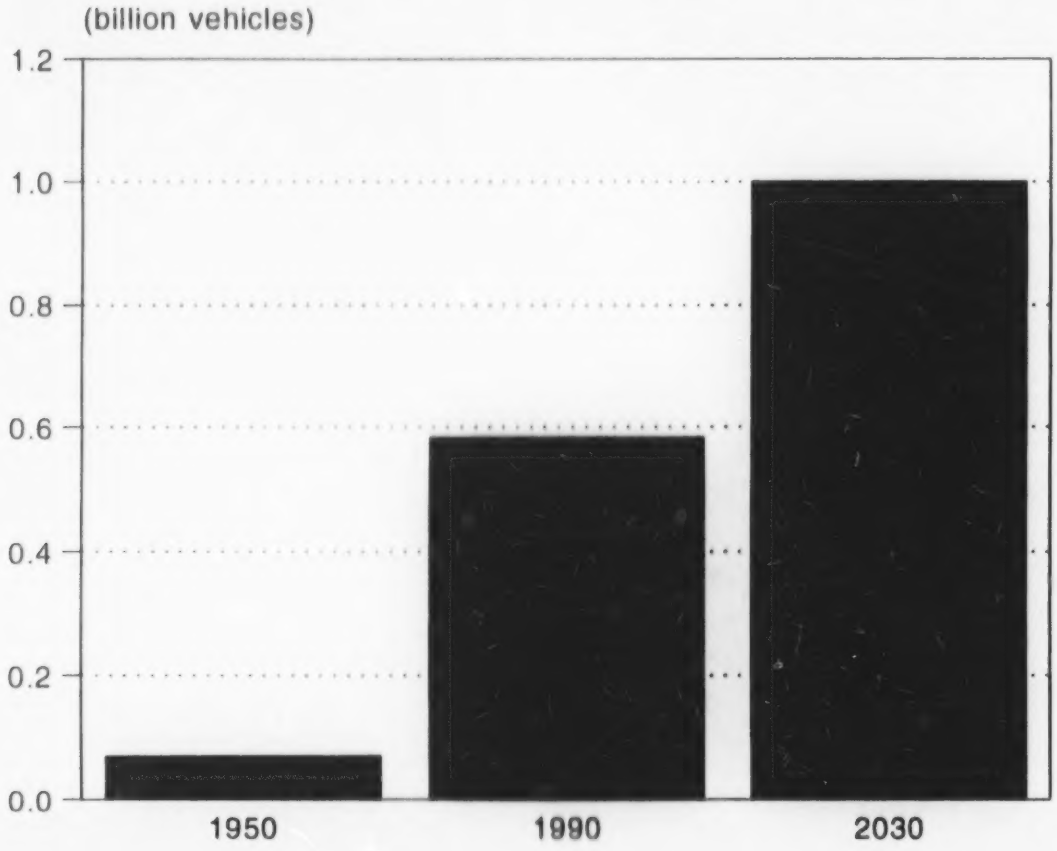
Sources: *Car Trouble* and *The Going Rate: What It Really Costs to Drive* (World Resources Institute, Washington, D.C.)

Emissions: A Triple Threat



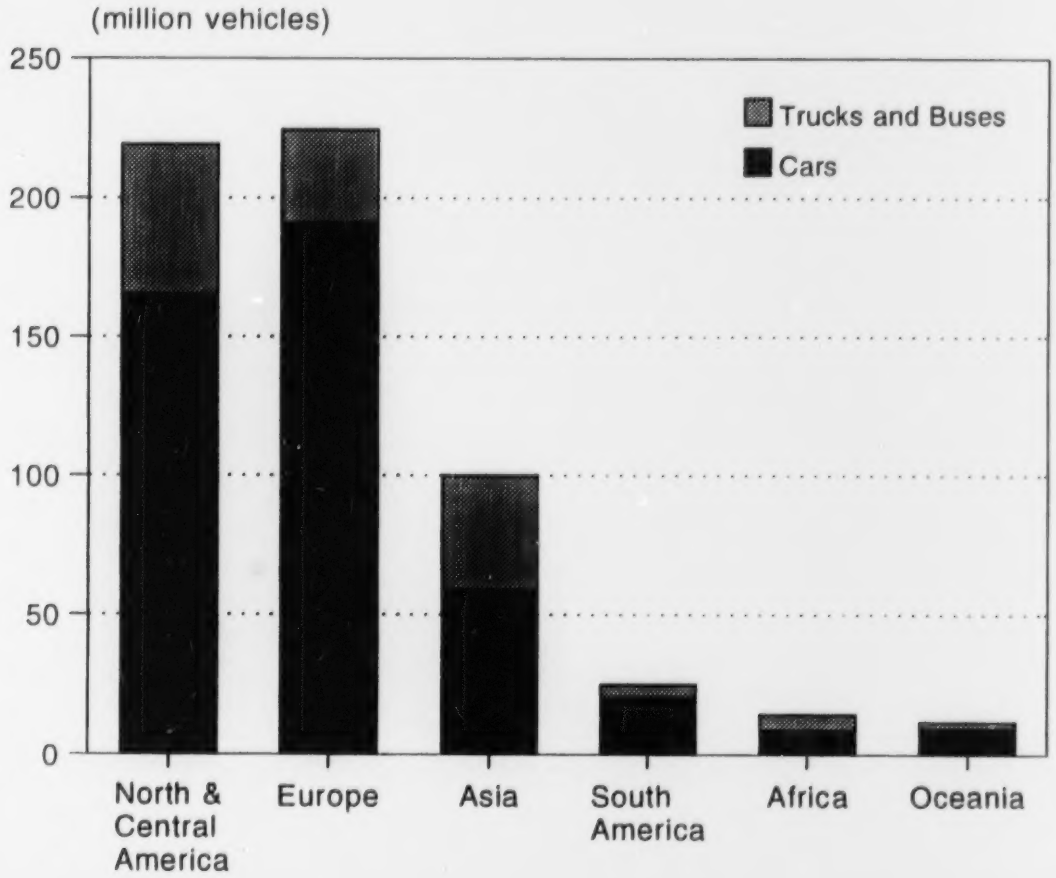
Computer Graphics by Susanne Kamalieh

Number of Vehicles in the World



Source: *AAMA Motor Vehicle Facts and Figures '93* (American Automobile Manufacturers Association, Detroit, 1993), p. 39.

Motor Vehicles in World Regions



Source: *AAMA Motor Vehicle Facts and Figures '93* (American Automobile Manufacturers Association, Detroit, 1993), pp. 39–42.

Note: Data refer to 1991. The data show that Europe has slightly more vehicles than North and Central America, however, Europe's total population (846 million) is twice that of North and Central America (417 million). Europe also has a ratio of persons per vehicle (3.8) that is nearly twice that of North and Central America (1.9).

Teacher's Survey
Teacher's Guide Units

(Please use additional paper if necessary)

1. Which *World Resources Teacher's Guide* unit did you use?

___1. Biodiversity
___2. Car Trouble
___3. Citizen Action
___4. Energy, Atmosphere, and Climate
___5. Natural Resource Economics
___6. Oceans and Coasts
___7. Population, Poverty, and Land Degradation
___8. Sustainable Development
___9. Two Giants: China and India
___10. Watershed Pollution
___11. Women, Equity, and Sustainable Development

2. Course(s) in which you used *World Resources Teacher's Guide* units?

___History ___Geography ___Science
___Ecology ___Biology ___Chemistry
___Environmental Studies ___Environmental Science ___Other

3. Which sections of the unit did you find most useful?

___Teaching Strategies
___Student Enrichment Activities
___Student Handouts
___Overhead Transparency Masters
___Reading and AV Lists

4. How much do you think you will use the *World Resources Teacher's Guide* units in the future?

___Often ___Occasionally ___Rarely

5. Did you use the Goals 2000 draft national performance standards to select material from the units?

___Yes ___No

6. If yes to the above question, which performance standards did you teach?_____

_____

7. Were the recommended activities in the unit useful in teaching those standards?

___Yes ___No

8. What features could be added to the *Teacher's Guide* to make it more useful to you?

_____

_____

_____

9. In what setting did you use the *Teacher's Guide* units?

___Middle school ___12th grade ___Nature center
___High School ___Community college ___Zoo
___10th grade ___College or university ___Museum
___11th grade ___Adult education ___Other

10. Was the material appropriate for your audience?

____Yes No, because_____

11. If you used the unit in a school, how much class time did you and your students spend on it?

____Less than 1 class ____2–3 classes ____1–2 weeks

____1 class ____4–5 classes ____More than 2 weeks

12. Do you regularly teach about global environmental issues?

____Yes ____No

13. If you don't regularly teach global environmental issues, did you find this unit offered enough information and materials to construct your lesson?

____Yes No, I also needed_____

14. Did you use other WRI materials with this unit?

____Yes ____No

If yes, which ones_____

15. Because new units of the *Teacher's Guide* are being developed, it is helpful for us to learn how the materials work. Did they engage your students? Prompt lively discussion? Help make what seemed abstract issues vivid? Please be specific with negative *or* positive comments.

_____

_____

_____

_____

Name_____

School or Organization_____

Address_____

_____

May we call you to discuss your suggestions?

____No Yes, I can be reached at_____

Please return to:

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